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AN ENERGY PRODUCTION EVALUATION FROM PV ARRAYS WITH DIFFERENT INTER-ROW DISTANCES

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ABSTRACT

Solar energy in Jordan is considered the most promising candidate to cover future energy needs. This is because of the high radiation rate in Jordan and solar could be utilized approximately 300 days per the year. Therefore, investing in solar energy generation is a successful investment in Jordan. This study compares the outputs of solar panel fields with different inter-row spacing. As the performance of grid-photovoltaic (PV) systems are affected by the array spacing. As it is clear that Increasing the spacing of the arrays aide in reducing the impact of shading losses, but at the same time, it increases the land used for this applications and the costs as well. Several technical factors are involved when selecting an optimum spacing

KEYWORDS: Solar Energy, PV Fields, Solar Radiation & Inter Row Spacing

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Original Article

INTRODUCTION

The energy situation in Jordan is the biggest burden and the biggest problem with more than 97 percent of the national income being Jordan's debt, the largest component of which is its high energy bill, especially in recent years because of the regional conditions surrounding Jordan. Consequently, the search for renewable alternative sources of energy is an urgent need to eliminate the effects of debt accumulation caused by its energy bills. Hence, the importance of solar energy as a basic player and an optimal solution to the problem of energy, because the rate of solar radiation is high [1–10]. Investment in renewable energy, particularly solar energy, is the most successful investment in Jordan [4, 11–16].

The investment in solar energy in Jordan is the country’s most successful investment. Jordan has more than 300 solar days during the year with a high solar radiation rate. However, the investment in renewable energy is stagnant, especially in solar energy. Because of the weakness in the national electricity grid, which makes it unable to receive the electricity generated from the different renewable energy systems. The problem of the stability in production, and the rate of variability and other economic problems. From here, several researchers all over the world conducted researches on the using of the renewable energy in Jordan [5–10, 16–34].

The analysis of self-shading between rows of the PV panels had been studied in early researches from the point of view related to incident energy. These studies allowed in a better understanding of the main design parameters involved in the shading effect and are applicable for both PV and solar thermal fields. Mathematical analysis approaches were presented to enhance annual energy on a given field, minimize the field area for a given annual energy, and maximize the annual energy per unit collector area from a given field is the goal of the studies around this topic [15].

Alnajideen et al. presented a study on the generation of electricity needed for a school building in Amman-Jordan and found that by installing a photovoltaic cell plant, the necessary electrical energy could be obtained [35]. Alnajideen and Alrwashdeh presented a study on the construction of a plant to cover the needs of the Faculty of Engineering at the University of Mutah, south of Jordan [36].

The design of photovoltaic systems is not easy because many of the factors are considered as determinants and obstacles that prevent the optimal use of PV systems. These factors are the available space for use, natural and climatic factors and the availability of solar radiation [37–42]. Several research papers on the use of solar energy, particularly photovoltaic cells, are available [43–48].

One of the factors that lead to the reduced electrical load generated from photovoltaic cells is the availability of enough space to be properly install the cells, which leads to the problem of loss of energy. This study compared the amount of energy produced by two fields of PV cells based on the different distances of the cells based on the using of the 3D-Energy simulation [7, 49–54]. The place chosen to complete the investigation is Ma'an governorate, southern Jordan about 170 km far away from Amman, the capital of Jordan, Ma'an lies within a latitude of 32 north and longitude of 36º east. The investigation is based on the 10th of December, the worst day for solar radiation production availability over the year.

SOLAR PV SYSTEM

Electrical power can be generated through solar energy directly based on using PV cells or indirectly through the concentrated solar systems. The design is based on the calculation of the amount of solar radiation daily, monthly and yearly and calculation the amount of solar radiation applied to the slanted surfaces, and the calculation of energy produced in general. All the previous can be calculated depending on a mathematical model [55–61].

In the beginning, the declination is calculated based on the worst day of the solar radiation, the 10th of December, in the second stage the solar sunset hour angle, the daily extraterrestrial radiation on a horizontal surface, the monthly average clearness index, the daily / monthly average diffuse radiation, and the hourly solar irradiation for the tilted surface are calculated. Finally, the energy output from the system is evaluated. The result is based on the simulation of the 3D-Energy simulator which is a magnificent tool to estimate such result [8, 10, 16, 62–64].

For an optimum PV performance which can extracted from the system the site must selected carefully based on several parameters such as:

- Climate and solar resource
- Topography and ground conditions
- Availability and accessibility of a grid connection from the site
- Environmental and social aspects
- Costs

RESULTS AND DISCUSSIONS

Solar radiation is the radiation received per unit area in the unit of Wh / m^2. figure 1 shows an overview of the 3D-Energy simulator run for this investigation. as it is clear that we have two solar PV fields with different inter-raw spacing between

the PV panels. As its mention before the aim of this investigation is to show the effect of the inter spacing effect on the energy production from the PV systems, through the studding the effect of the different losses effect such as the blocking and the shadowing and others factors.

This study illustrates the effect of inter-row spacing on the energy output of a solar panel arrays with a fixed tilt angle. Each solar panels rack is installed with a different landscape orientation. The paper task is to evaluate the outputs of the two different solar panel fields with a different inter-row distances.

A way to compare the energy outputs of the two PV systems is to use the "Annual Analysis for Energy production" The results will show the outputs of the solar panels on each foundation month by month around the year as well it will show the result of the worst day over the year which is the 10th of December.

Figure 2 shows the result of the simulation of the two solar photovoltaics (PV) fields with different inter-row spacing after it operating over the 10th of each month over the year at Ma'an-Jordan. The maximum output energy over the year was between May and September. While, the lowest was from January to April and from October to December.

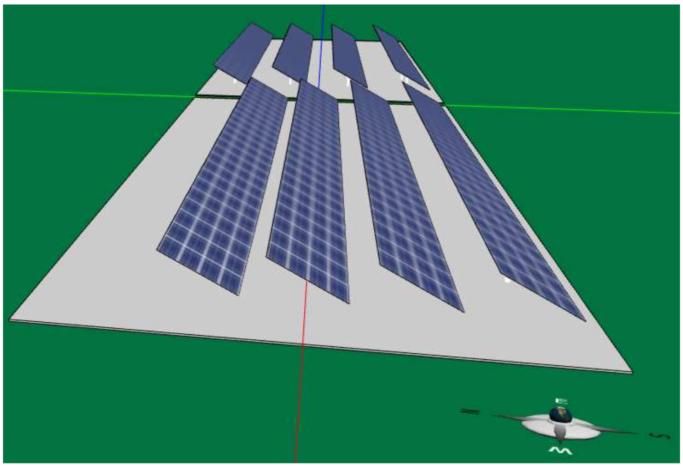

Figure 1: Two PV Fields with Different Inter-Raw Spacing.

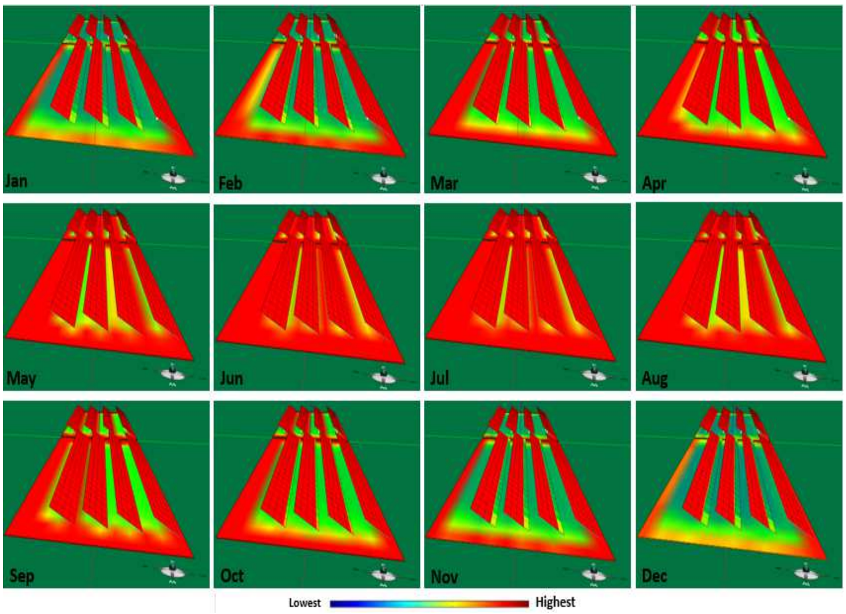

Figure 2: Simulation Result of Each Month of the Year.

The energy production from the PV fields depends on several factors such as size, efficiency and the received radiation that the panel gets. Figure 3 shows the energy production from the solar PV fields with a different inter-row spacing on the 10th of December as it considers the worst solar radiation day over the year for the selected site of the investigation, which is Ma'an-Jordan. It possible to observe that: The maximum energy production was related to the PV field with the sufficient inter-row spacing with an energy production of 377 kwh. While, the production of the field with the insufficient inter-row spacing of 318 kWh.

Figure 4 shows the energy output from the PV fields with different inter-row spacing at Ma'an-Jordan over the year, in kWh. The maximum energy output over the year was for the system with a sufficient inter-row spacing with an energy output of 6631 kWh / year. The field with insufficient inter-row spacing has an energy output of 6141 kWh / year.

The PV array row spacing should be carefully selected to minimize the effect of shading on the amount of power produced. Figure 5 shows the best way to install a PV system. As β the tilt angle of the PV panel and x distance represent the space between the PV panels [49, 65–67].

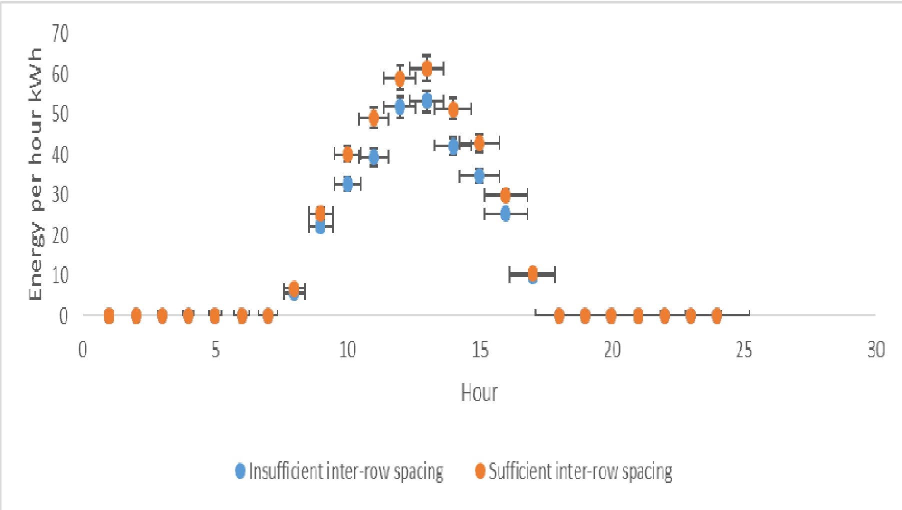

Figure 3: Energy Output at 10th of December for the PV Fields with Different Inter-Row Spacing.

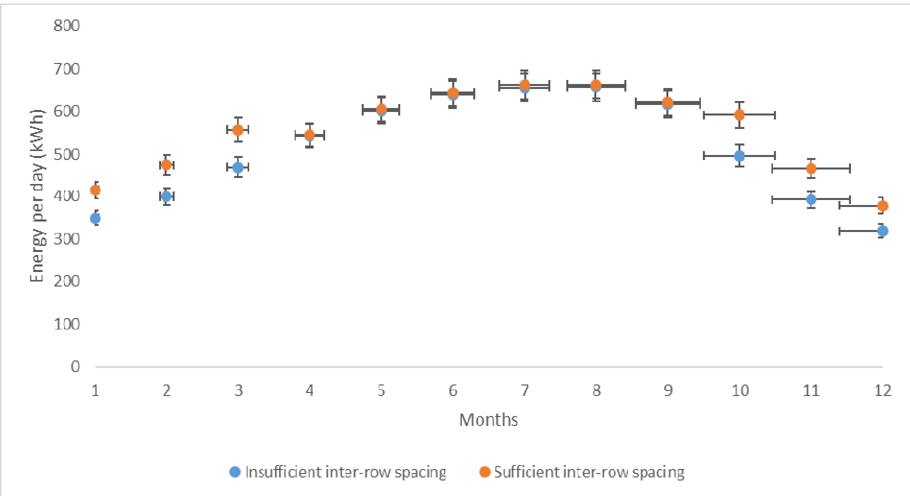

Figure 4: Output Energy During the Year for the PV Fields with Different Inter-Row Spacing.

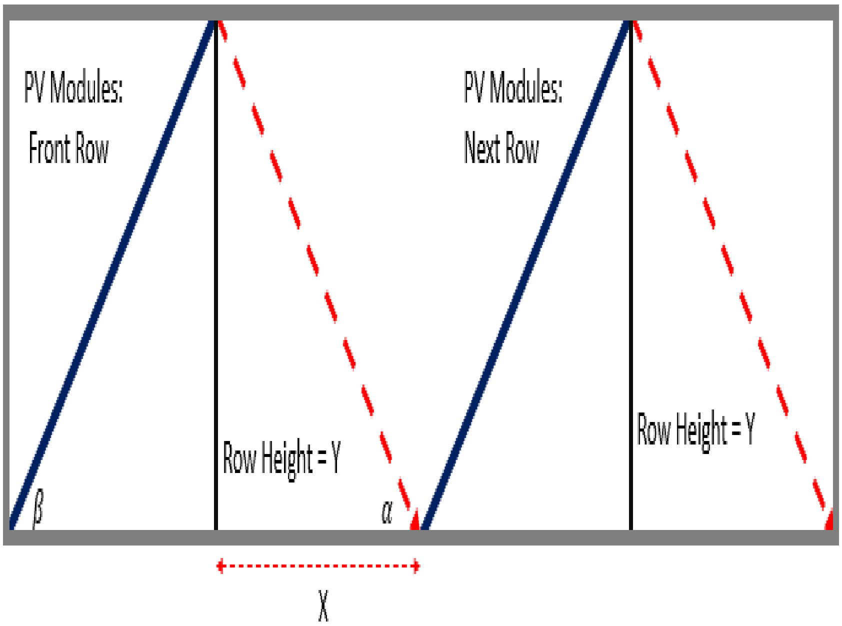

Figure 5

CONCLUSIONS

Optimization methodology for the spacing in grid-connected PV systems have been presented. It uses annual losses energy calculations, energy produced different models of the PV system are studied. In this way, several considerations are taken such as some technical parameters that impact the optimum array spacing. It has been applied to the climate of Amman-Jordan, by using real atmospheric measurements based on the 3D-Energy simulator. However, the methodology can be easily applied to other locations with available climate data.

The production of the PV fields is studied with Appling different inter-row spacing. It is found from the results of the simulation thatthe maximum energy output for the PV fields was for the PV field with the sufficient inter row spacing, with an energy production of 6631 kWh / year. While the minimum output of energy was 6141 kWh / year for the PV field with insufficient inter-row spacing.

During the winter months over the year January through March and October through December the deviation in the energy production appears very well, while the rest of the year the two fields have the same amount of the energy production because of the perpendicular rays to the fields. Over the worst day of the year, which is the 10th of December, the energy production is started between 07:00 AM till 04:00 PM.

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